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(54) Process for biological cleaning of wastewaters, particularly of municipal origin.

(57) Process for biological cleaning of wastewaters, characterized in that the wastewaters are transferred from a mechanical preclarification stage into a buffer basin, moved from that by a metering pump to a biological filter such as a wrapped perforated drainage pipe laid down in flowing water, and the microbial degradation of C and N is accomplished by nitrification and denitrification such that the bacteria get O_2 from the O_2 content of the flowing water by diffusion inward through the pores of the biological filter, resulting in comparative evening out of the practically cleaned wastewater; that the biological filter is placed in a tank with aerated flowing water; and that the biological C and N degradation occurs in a bypass to the flowing water.

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Description

Reduction of environmental stress by wastewater, especially domestic wastewater, is an economically important objective.

The subject of the invention is a process for biological cleaning of wastewaters, especially those of municipal origin.

It is possible, at the state of the technology, to carry out a biological degradation by adding microorganisms to the organic pollutants and nitrogen compounds, with oxygen supplied by forcing air in to the point of O_2 limiting.

The process of the invention avoids this capital cost and the high operating cost of stirring and air supply.

The objective of the process of the invention is cleaning wastewaters contaminated with organic substances and nitrogen compounds by biological degradation in a technologically simple way to the extent that it can be introduced into flowing water to take the load off its self-cleaning capacity.

The process of the invention is defined in Patent Claims 1 and 2. The subclaims claim the alternative and preferred embodiment.

One technical effect of the process of the invention is based on combination of the wastewater to be cleaned with the water from flowing water. It is surprising that the O_2 content of flowing water can be utilized to supply O_2 to bacteria to promote growth through diffusion in through the pores of a biological filter.

A further technological effect consists of evening out the introduction of the biologically cleaned wastewater into the flowing water.

To the extent that drainage pipes with pores are used preferably as biological filters, they are wrapped with natural and/or synthetic fibers. Such tubes are manufactured by Fränkischen Rohrwerken, Königsberg, Bavaria.

These perforated pipes use one or more layers of inorganic material such as mineral wool, or organic material such as coir as trickling and filter surfaces of the biological filter.

The support elements used with drainage pipes can consist of multiple concentric pipes such as stainless steel frameworks.

A biological filter is understood to be a perforated tubular body of inorganic or organic material through which wastewater flows and, in the interior and on the covering layer of which a biological system develops with microorganisms naturally present in the wastewater, after an initial phase.

Apparently the wastewaters develop a stepped biological system in the biological filter which causes nitrification even in the outer layer and also denitrification in the inner layer of the biological filter. According to the process of the invention, for example, a biologically cleaned wastewater can be produced with a continuous input of 0.5 – 20 m^3 municipal wastewater in 24 hours. The O_2 supply of the colonizing microorganisms is through continuous contact with the flowing water. There can also be mixtures and dilutions with the flowing water in the interior of the perforated tubular biological filter. But the wastewater introduced always flows through the biological filter before leaving along the length of the tubular filter.

This results in the maximum biological degradative power in the interior of the biological filter. A sludge forms in the biological filter from the input to the middle of the pipe. By the end of the pipe it exhibits good settling behavior because of its consistency. This sludge is periodically pumped back to the mechanical preclarification stage through a central internal back-flush pipe, and is periodically withdrawn from there.

The process of the invention is explained by the following chemical analyses:

	Sample 1 Input [to] wastewater treatment	Sample 2 Valve 1	Sample 3 Valve 2
pH	7.7	8.0	7.7
Ammonium (mg/L)	231	99	0.06
Ammonium nitrogen (mg/L)	180	77	0.05
Nitrate (mg/L)	1.8	8.6	18.2
Nitrate nitrogen (mg/L)	< 0.5	1.9	4.1
Nitrite (mg/L)	< 0.01	6.2	0.07
Nitrite nitrogen (mg/L)	< 0.005	1.9	0.02
Total nitrogen (mg/L)	209	89	5.5
Total phosphate phosphorus (mg/L)	13.4	5.60	0.20
Chloride (mg/L)	170	76	28
BOD_5 (mg/L)	135	50	24
COD, homogenized (mg/L)	401	160	230
COD, filtered (mg/L)	188	83	< 10
COD, settled (mg/L)	348	116	< 10

	Sample 4 Stream sample after clarification system	Sample 5 Stream sample before clarification system	Sample 6 From clarification system at input, outer layer
pH	7.8	7.7	7.9
Ammonium (mg/L)	0.12	0.09	0.2
Ammonium nitrogen (mg/L)	0.09	0.07	0.16
Nitrate (mg/L)	17.1	17.0	19.0
Nitrate nitrogen (mg/L)	3.9	3.8	4.3
Nitrite (mg/L)	0.08	0.09	0.08
Nitrite nitrogen (mg/L)	0.02	0.03	0.02
Total nitrogen (mg/L)	4.0	3.9	--
Total phosphate phosphorus (mg/L)	0.15	0.11	0.14
Chloride (mg/L)	28	28	33
BOD_5 (mg/L)	< 5	< 5	--
COD, homogenized (mg/L)	< 10	< 10	--
COD, filtered (mg/L)	< 10	10	< 10
COD, settled (mg/L)	< 10	10	--

	Sample 7 From clarification system 3 m before the end of the system; outer layer	Sample 8 Stream water 10 cm after clarifier tube at the pipe input	Sample 9 Stream water 10 cm behind pipe 3 m before end
pH	--	7.8	7.7
Ammonium (mg/L)	0.1	0.09	0.09
Ammonium nitrogen (mg/L)	0.08	0.07	0.07
Nitrate (mg/L)	17.9	17.7	17.3
Nitrate nitrogen (mg/L)	4.0	4.0	3.9
Nitrite (mg/L)	0.09	0.08	0.08
Nitrite nitrogen (mg/L)	0.03	0.02	0.02
Total nitrogen (mg/L)	--	--	--
Total phosphate phosphorus (mg/L)	--	0.16	0.24
Chloride (mg/L)	--	28	27
BOD_5 (mg/L)	--	--	--
COD, homogenized (mg/L)	--	--	--
COD, filtered (mg/L)	< 10	< 10	< 10
COD, settled (mg/L)	--	--	--

Sample 1 shows a high content of ammonium (NH_4) corresponding to NH_4-N. That has been practically completely degraded microbiologically past Sample 3 and is equivalent to the flowing water in Sample 9. On the other hand, the nitrate content increases from Sample 1 to Sample 3, remaining practically constant after that until Sample 7, and is equivalent to the nitrate content of the stream water (Sample 9).

The nitrite content increases from Sample 1 to Sample 2 and decreases from Sample 3 to Sample 7, and is equivalent to the nitrite content of the stream water.

As the nitrite content increases temporarily and exceeds the nitrate content of the surrounding water at Sample 6, that confirms the nitrification and denitrification.

Samples 1 – 7 show a decreasing phosphate/P content (P_2O_5/P) equivalent to Sample 9 of the stream water.

Samples 1 – 3 show a decreasing chloride (Cl) content which is equivalent to the stream water of Sample 9 after Sample 4.

The BOD_5 decreases from Sample 1 to Sample 3 and is less than 5 mg/L at Sample 4.

The COD decreases after Sample 1. In all the samples, the filtered COD is equivalent to Sample 9 of the stream water.

The measurement BOD_5 means:
Five-day biological oxygen demand.

The measurement COD means:
Chemical oxygen demand.

In the Table: Valves 1 and 2: screw holes in the tubular biological filter for sample collection from the interior of the tube.

The process of the invention is also explained by the following microbiological examinations:

	Sample No. 1	Sample No. 2	Sample No. 3	Sample No. 4	Sample No. 5	Sample No. 6	Sample No. 7
Total bacterial count at 37 °C CFU/ml [see Tr. note]	$3.2 \cdot 10^3$	$2.7 \cdot 10^6$	$4.5 \cdot 10^5$	$1.8 \cdot 10^4$	$1.9 \cdot 10^4$	$1.1 \cdot 10^4$	$6.0 \cdot 10^3$
Total bacterial count at 20 °C CFU/ml [see Tr. note]	$3.9 \cdot 10^3$	$4.7 \cdot 10^6$	$8.6 \cdot 10^6$	$7.1 \cdot 10^4$	$1.7 \cdot 10^5$	$8.7 \cdot 10^5$	$5.4 \cdot 10^4$
E. coli + coliforms	+	+	+	-	-	-	-
Fecal streptococci	-	+	+	-	-	-	-
Gram-negative rods CFU/ml	$1.1 \cdot 10^3$	$> 10^4$	$> 10^4$	$1.2 \cdot 10^3$	$3.4 \cdot 10^3$	$1.8 \cdot 10^3$	$1.6 \cdot 10^3$
Yeasts and molds CFU/ml	$3.0 \cdot 10^1$	$\sim 10^4$	$\sim 10^4$	$8.7 \cdot 10^2$	$\sim 10^3$	$\sim 10^3$	$8.0 \cdot 10^2$
Anaerobes	-	+ Spore-formers	-	-	+ Spore-formers	-	-

[Translator's note: the "Keimzahl" is literally a 'microbial count' but in fact is normally a 'bacterial' count (i. e., not including yeasts and molds.)]

The microbiological examinations confirm the results of the chemical analyses.

The total bacterial count [see Tr. note] increases strongly from Sample 2 to 4. Also, at Sample 4, no coliforms or fecal streptococci are found. Other microorganisms such as Gram-negative rods are on the order of that in the surrounding stream water.

Meanings:
CFU: colony-forming units
Sp.: spore-forming microorganisms
- no organisms detected
+ organisms detected.

The process of the invention is explained by the following figures:
Figure 1: Process diagram with part of the equipment and the biological degradation unit.
Figure 2: Constructive diagram of the cross section of the drainage pipe.
Figure 3: Marking of the sites where samples were taken for chemical analyses.
Figure 4. Marking of the sites where samples were taken for microbiological examinations.

The characters in the figure have these meanings:

Reference character list

1	Mechanical preclarification stage/multichamber basin
2	Buffer basin
3	Metering pump
4	Biological degradation unit / drainage unit
5	Support elements (lacking in Figure 2)
6	Backflush pipe
7	Backflush pump

A1	Perforated pipe
A2	Filter material
B1	Perforated pipe
B2	Filter material
C1	Perforated pipe / framework as protective covering
C2	Perforated pipe
C3	Filter material
D1	Perforated pipe / framework as protective covering
D2	Perforated pipe
D3	Filter material

Meanings in the figures for sample collection sites for the investigations:

Figure 3: Chemical analyses

1 Input to pipe or output from multichamber basin
2 Valve 1
3 Valve 2
4 Stream sample following the clarification system
5 Stream sample ahead of the clarification system
6 From the outer layer of the clarification system near the input
7 From the outer layer of the clarification system, 3 meters before the end of the system
8 Stream water past 10 cm behind the clarification pipe in the vicinity of the input
9 Stream water past 10 cm behind the clarification pipe 3 meters before the end of the pipe.

Figure 4: Microbial examination

1 Stream water before the clarification system
2 Inlet to clarification pipe
3 Valve 1
4 Valve 2
5 From the outer layer, first region
6 From the outer layer, second region
7 From the outer layer, third region.

The process of the invention offers the advantage that extensive biological cleaning and denitrification can be attained with low capital cost and low operating costs, with continuous flow through of contaminated wastewaters, which allows introduction of the cleaned wastewater into the flowing water.

That is, therefore, also linked with improvement for the environment.

Patent Claims

1. Process for biological cleaning of wastewaters, especially of municipal origin, characterized in that the wastewater is transferred , or in the general case, overflowed, from a mechanical preclarification step (1), preferably a multichamber clarifying basin, continuously or discontinuously into a buffer basin (2), and from there is moved by a metering pump (3) into a biological filter (4), preferably made of one or more concentric, wrapped, perforated drainage pipes which lie flat in flowing water, and the microbial C degradation of the polluting organic material and the N-containing compounds loading up the N degradation are accomplished by nitrification and denitrification such that the naturally present bacteria obtain the required oxygen from the O_2 content of the flowing water through continuous diffusion inward through the pores of the biological filter, and the biological filter accomplishes evening out of the practically biologically cleaned wastewater which flows out into the flowing water over the entire length of the biological filter.

2. Process as a modification of the process according to Claim 1, characterized in that the biological filter (4) is placed in a holder with aerated flowing water and the microbial C degradation and the N degradation occurs in a bypass to the flowing water.

3. Process according to Claims 1 and 2, characterized in that the biological filter (4) comprises perforated drainage pipes 10 – 20 m long with inside diameters of 5 – 20 cm.

4. Process according to Claims 1 to 3, characterized in that the perforated drainage pipe (A1) has an attached inner ring of filter material (A2)
or the perforated drainage pipe (B1) also has an internal supported concentric ring (B2) of filter material (B2),
or the perforated drainage pipe (C1) comprises a framework as a protective cover, particularly a stainless steel framework, and also has an internal supported concentric ring (C2) of filter material (C3),
or the perforated drainage pipe (D1) or framework (D1) has 2 internal supported perforated drainage pipes (D2; D3) with an attached internal ring of filter material;
or a shape differing from the geometric shape of the drainage pipe is used.

5. Process according to Claims 1 and 2, characterized in that multiple biological filters are arranged generally in parallel as sections.

6. Process according to Claims 1 and 2, characterized in that the sludge formed in the interior of the tubular biological filter is periodically pumped back through the backflush pipe (6) into the mechanical preclarification stage (1) and is withdrawn from that.

Accompanied by 4 pages of drawings

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Figure 1

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Figure 2

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Figure 3

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Figure 4